Does the distribution of emission permits matter for international competitiveness?

Florent Pratlong

– PANTHÉON - SORBONNE –
UNIVERSITÉ PARIS 1

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DOES THE DISTRIBUTION OF EMISSION PERMITS MATTER FOR INTERNATIONAL COMPETITIVENESS?

Florent PRATLONG [1,2]

[1] ERASME, Ecole Centrale Paris. EUREQua and PRISM-LASI, Université Paris I *Panthéon-Sorbonne*. E-mail: fpratlong@ecp.fr.

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Abstract

This paper analyzes the implications of the distribution of emission permits related to a strategic environmental policy and shows how it alters the competitive relation among firms in the international product market. Our model introduces permits trading into the Brander-Spencer [1985] framework. It analyzes a class of two stages Cournot game involving two governments (Home and Foreign) and their respective industry. It shows the incentive for the Home government to distort its initial distribution of permits from the first-best rule to achieve trade-related policy objectives, enabling its domestic producers to improve their market shares. We establish that the Home government implements a higher distribution of permits than the optimal level.

Keywords: Tradable emission permits, international oligopoly, strategic policy.

JEL Classification: F13, F18, Q28.

Résumé

Ce papier analyse les implications de la distribution des permis d'émission dans le cadre d'une politique environnementale stratégique et montre comment elle modifie les relations concurrentiels entre entreprises sur le marché international du produit. Notre modèle introduit un marché de permis d'émission négociables dans un modèle à la Brander et Spencer [1985]. Il analyse une classe de jeu à la Cournot en deux étapes entre deux gouvernements (Domestique et Etranger) et leur industrie respective. Il montre l'incitation du gouvernement domestique à distordre sa distribution initiale de permis de la règle de premier rang pour atteindre des objectifs commerciaux, permettant à leur producteurs domestiques d'améliorer leurs parts de marché. Nous établissons que le gouvernement Domestique met en oeuvre une distribution de permis plus importante que le niveau optimal.

Mots-clés : Permis d'emission négociables, oligopole international, politique stratégique.

Classification JEL : F13, F18, Q28.

1 Introduction

Facing pollution problems, the industrialized countries are engaged in reducing their emissions. In particular, imposing a permits trading system is an effective means to implement a domestic environmental policy. First proposed by Dales [1968], a tradable emission permits regulation represents a system of tradable property rights for the management of environmental pollution. This market-based system allows polluters to trade their emission reductions to achieve a target cap on the aggregate level of emissions. Each polluter, emitting more than its target, is allowed to purchase emission permits from an other polluter, which in turn reduces its emissions below its target. Then, trading of permits yields to minimization of abatement costs. The advantages of such a tradable emission permits approach has been widely discussed in Baumol and Oates [1988] and Xepapadeas [1997].

One major difficulty facing policy makers, beyond establishing a domestic permits trading market, is to determine the initial cap for the total level of allowable pollution because it has distributional implications among firms in the international output market. Indeed, at the worldwide level, the environmental policies in permits trading might diverge owning to each country's collective choice. Then, it won't be surprising if international differences in the domestic distribution of permits may lead to distort competitiveness relation. This issue is all the more important since the distribution of permits is done through a "grandfathering" mechanism, that is all permits are freely allocated based on historical level of emissions. Dijkstra [1999] argues that grandfathering enhances the political acceptation of a tradable permits regulation because polluting sources need only to acquire their additional emission reductions up to their initial endowment of permits. Therefore, if firms receive their permits for free, they obtain a form of capital gift (Romstad [1999], Kling and Zhao [2000]), which might influence profits and the decision in output level.

It need to pay more attention to the link between competitive distortion aspects on the international product market in relation to the initial distribution of permits. Van der Laan and Nentjes [2001] develop two interpretations of competitive distortion concept associated with the introduction of an environmental policy regulation: as an inefficiency in the allocation of resources and as an inequity in firms' starting conditions. A competitive distortion, then, appears if countries implement different distribution of emission permits. The problem is that a government distort its distribution of permits, *ie.* allocate a generous amount of grandfathered permits, in an attempt to advantage its domestic firms in the international trade, thereby altering the fairness of competitive relation among firms. Then, in a manner of strategic distribution of permits, grandfathering may be interpreted as a form of implicit subsidization according to the WTO rules or as a form of "State Aid"[3] under the European Community law. In fact, without any harmonized procedures of permits distribution, the initial allocation of permits may be used as a strategic instrument to affect the international trade conditions.

In support of this idea, our paper develop a model of strategic distribution of emission permits within the trade policy framework of Brander-Spencer [1985]. Their original model shows that governments have incentives to export subsidization in a strategic fashion to try to affect trade patterns in favor of their domestic firms. However, since international trade agreements restrict the use of trade instruments, environmental policy appears as a feasible substitute to extract foreigners' rents. Then, this focus leads to the concept of "ecological dumping". Indeed, a substantial literature in the last decade had investigated the relationship between strategic environmental policy and international trade. Rauscher [1994] defines ecological dumping as a " policy which prices environmentally harmful activities at less than the marginal cost of environmental degradation". In this case, governments implement less stringent environmental policy in terms of hidden subsidy by means of weaker pollution abatement objectives. These results are established by Barrett [1994] and extended by Ulph [1996] in the context of strategic environmental standards. Conrad [1993] and Kennedy [1994] consider also the implications of a strategic environmental taxation. Others, as Sartzetakis and Constantatos [1995], investigate the impact of differences in environmental regulation on international competitiveness. While these studies provide considerable insights into the use of environmental policy as a surrogate of strategic trade policy, none have yet attempt to analyze trade strategic implications of environmental policy within the context of emission permits.

The purpose of our paper is to extend the existing literature to the case of emission trading. Our focus differs from the previous studies in that, in stead of considering only the level of environmental policy, it derives explicitly the conditions of a tradable emission permits regulation. Hence, it deals with the incidences of the initial distribution of permits on international trade patterns. The paper is organized as follows. Section 2 describes the general framework and defines the trade equilibrium in an international Cournot-Nash industry under different national tradable emission permits regulation. Then, we turn to focus both on the optimal and the strategic distribution of permits. Section 3 discusses the implications of the initial distribution of permits. Section 4 offers conclusion.

[3] EC Article 87(1) considers "any state aid by a Member Ste or through State resources in any form whatsoever which distorts or threatens to distort competition by favouring certain undertakings or the production of certain goods shall, in so far as it affects trade between Member States, be incompatible with the common market".

2 The model

The following paper is able to incorporate incentives for governments to manipulate their abatement requirements in setting a domestic tradable emission permits market. We set out a simple model to explain how a strategic distribution of emission permits can support a claim that governments might seek to distort their environmental policy, resulting in "ecological dumping".

Assume a two-sector economy, with a numeraire sector and a homogeneous oligopoly sector, generating emissions of a pollutant. Consider a partial equilibrium analysis dealing with the oligopolistic industry. There are two countries, indexed by $i = h, f$, referred to as the Home country and the Foreign country respectively. The industry in each country, consisting of n oligopolists, indexed by $j = 1, ..., n$, are the sole producers at the world market of a commodity. Denote by q_{ij} the output level of the firm j located in the country i. It is further assumed that there are no consumers of the product located in these country. Thus, all production is for export in a third country in which inverse demand is assumed linear of the form : $p = 1 - \sum_{j=1}^{n} q_{hj} - \sum_{j=1}^{n} q_{fj}$. The competition on the side of the exporting firm is *à-la* Cournot-Nash. Firm ij faces a total cost of production $C_{ij}(q_{ij}) = c_i q_{ij}$, different across countries and identical across oligopolists in the same country, where c_i is a technological parameter representing the constant marginal cost of production in the country i.

Consider, as reference case, a situation in which the governments don't impose any constraints on the level of pollution. Each firm j in the country i chooses its level of output to maximize its profits $\Pi_{ij} = (p - c_i)q_{ij}$. Thus, we can determine the level of output for each country, the corresponding international product price and the profit earned by each firm $j = 1, ..., n$ located in the country $i, -i = h, f$.

$$\hat{q}_{ij} = \frac{1 + nc_{-i} - (n+1)c_i}{2n+1} \quad (1)$$

$$\hat{Q}_i = n\frac{1 + nc_{-i} - (n+1)c_i}{2n+1} \quad (2)$$

$$\hat{p} = \frac{1 + n(c_i + c_{-i})}{2n+1} \quad (3)$$

$$\hat{\Pi}_{ij} = [\hat{q}_{ij}]^2 \quad (4)$$

where the uperscript ˆ denotes the variables' value at the trade equilibrium without any environmental regulation.

Production involves pollution generating a negative externality, which harms the environmental quality. Emissions of the pollutant are taken to be a by-product of output. For each firm j located in the country i, emissions are given by $e_{ij} = \rho q_{ij}$ where ρ denotes the rate of emissions per unit of output. Producers can reduce their pollution by choosing the level of their abatement effort α_{ij}. Further, the cost of abatement is assumed quadratic[4] in the level of abetement effort in the form $A_{ij}(\alpha_{ij}) = \beta_{ij}\alpha_{ij} + \alpha_{ij}^2$, where β_{ij} represents a technological-specific parameter. Hence, each industry is characterized by a heterogeneous cost of abatement profile within the same country and a symmetric abatement cost structure across countries. In the sense that $\beta_{ij} < \beta_{i-j}$ for a given level of output, firm j in the country i is referred to as a lower-abatement cost firm than its rival firm $-j$. Therefore, firm j is facing a lower expenditures in reducing emission discharges. The symmetric cost structure in abatement activities between countries allow us to remove all shifts of market shares induced by any technological advantages from one country.

The reason producers need to abate the discharges of the pollutant is that governments in each country decide to reduce pollution by implementing an economic incentive mechanism through a tradable emission permits system. Thus, the regulatory regime through which environmental regulation is sought is a "cap and trade" permits system. The environmental regulatory authority in the two countries impose a constraint on the aggregate emissions by setting a cap $\bar{E}_i = \Psi_i \hat{E}_i$ on pollution. $\hat{E}_i = \rho \hat{Q}_i$ is the pre-regulation level of emission and Ψ_i denotes the degree of the abatement requirements. $\bar{E}_i$ represents then the inelastic supply of tradable permits issued by the national regulator distributed to the existing firms, ie. the "cap" for the total level of allowable emissions. Permits are allocated free of charge by initiating a "grandfathering" system, which gives them away on the basis of firms ' historical pre-regulation level of emission. Let $\bar{e}_{ij} = \Psi_i \rho \hat{q}_{ij}$ be the firm ij 's initial permits holding with $\sum_{j=1}^{n} \bar{e}_{ij} = \bar{E}_i$. Hence; the variable Ψ_i can be considered as the portion of permits initially grandfathered by the national environmental authority (associated with its emission limits objectives).

Each permits specifies an amount of allowable emission for one unit of pollutant. After initial distribution, permits can be freely traded among firms in the same country i. Assume the permits market is regarded as approximately competitive, and thus, firms behave as price takers in this market [see Malueg, 1990]. Firm ij's net demand for permits depends on its initial permits endowment and its abatement effort, $NE_{ij}(q_{ij}; \alpha_{ij}) = e_{ij} - \alpha_{ij} - \bar{e}_{ij}$ for $i = h, f$ and $j = 1, ..., n$.

The move structure of the model consists of a two stages game approach. In stage 1, each government specifies the level at which it sets its environmental policy (ie. the initial distribution of emission permits). Afterwards in stage 2, the domestic and foreign firms simultaneously determine their market strategy to choose

[4] The assumption of quadratic abatement costs structure leads to a downward slopping demand curve for tradable emission permits.

their output and abatement levels. The market structure is characterized by a competition of Cournot-Nash type on the international product market and a perfect competitive equilibrium on the tradable emission permits market in each country. The governments, acting non-cooperatively, play Nash against each other and Stackelberg *vis-à-vis* the firms to set their cap of permits endowment. Then, it's assumed that governments are able to pre-commit themselves prior to the decisions of the producers. This ability provides incentives for governments to engage in strategic behavior to extract foreign-rents towards their own industry. Following the usual concept of backward induction fashion, we turn to the market strategy first and then to the governments' decisions. The sequential structure of the model gives rise to a subgame perfect Nash equilibrium for the full game [Selten, 1975].

2.1 The trade equilibrium in the Cournot-Nash industry

Assuming competitive equilibrium for permits, the firms choose production levels and abatement efforts taking the permits price P_i^{tep} as given. Firm ij 's profit maximization problem becomes for $i = d, f$ and $j = 1, ...n$:

$$\max_{q_{ij},\alpha_{ij}} \Pi_{ij} = pq_{ij} - C_{ij}(q_{ij}) - A_{ij}(\alpha_{ij}) - P_i^{tep} NE_{ij}(q_{ij}, \alpha_{ij}) \tag{5}$$

The necessary first-order condition for Cournot-Nash equilibrium choice of output and abatement can be written as:

$$\frac{\partial \Pi_{ij}}{\partial q_{ij}} = 1 - 2q_{ij} - \sum_{\substack{k=1 \\ k\neq j}}^{n} q_{ij} - \sum_{j=1}^{n} q_{-ij} - c_i - \rho P_i^{tep} = 0 \tag{6}$$

$$\frac{\partial \Pi_{ij}}{\partial q_{ij}} = P_i^{tep} - \beta_{ij} - 2\alpha_{ij} = 0 \tag{7}$$

Optimization indicates that each firm chooses to trade permits to the point that its marginal cost of abatement equals the marginal cost of an additive permits measured by the permits price P_i^{tep}. The first-order condition [7] yields hereafter the corresponding optimal abatement effort:

$$\tilde{\alpha}_{ij} = \frac{P_i^{tep} - \beta_{ij}}{2} \tag{8}$$

where the uperscrpit $\sim$ denotes the variables' value at the trade equilibrium with permits trading.

Rearranging condition [6], we obtain firm ij's best reaction function r_{ij}, derived for a given permits price:

$$r_{ij} = \frac{1}{2}\left[1 - \sum_{\substack{k=1 \\ k\neq j}}^{n} q_{ij} - \sum_{j=1}^{n} q_{-ij} - c_i - \rho P_i^{tep}\right] \tag{9}$$

Firm ij's output reaction function are negatively sloped as the domestic and the foreign goods are perfect substitutes [Bulow et *al.*, 1985]. Moreover, if the domestic permits price is reduced, then the domestic firm's reaction function is shifted outwards. Under Cournot-Nash competition in the international product market, trade equilibrium is determined by the following optimal variable levels:

$$\tilde{q}_{ij} = \hat{q}_{ij} + \rho\frac{nP_{-i}^{tep} - (n+1)P_i^{tep}}{2n+1} \tag{10}$$

$$\tilde{Q}_i = \hat{Q}_i + n\rho\frac{nP_{-i}^{tep} - (n+1)P_i^{tep}}{2n+1} \tag{11}$$

$$\tilde{p} = \hat{p} + n\rho\frac{P_i^{tep} + P_{-i}^{tep}}{2n+1} \tag{12}$$

Trading in permits affects several aspect of market interaction, such that it changes the trade equilibrium values and thus affects the output levels and the price. The environmental regulation, via a national tradable permits system, sets additional costs to firms. However as at the Cournot-Nash equilibrium, firm's marginal costs of abatement equal the permits price, then, firms' market shares in the same country are not modified by trading in permits.

Lemma 1 *Firms' share among countries on the international product market are affected according to the relative spread between the domestic and the foreign permits prices.*

The aggregate output level $\tilde{Q}_i$ under a national permits regulation is decreasing in relation to its ex-ante level $\hat{Q}_i$, if $P_i^{tep} > \frac{n}{n+1}P_{-i}^{tep}$. Besides, in the case of a domestic permits trading regulation, firms may increase their profit $\tilde{\Pi}_{ij}$ in comparison with its ex-ante level $\hat{\Pi}_{ij}$ in the non regulated case. This possibility comes from a technological superiority or a more favorable distribution of permits.

$$\tilde{\Pi}_{ij} = \left[\frac{1 + n(c_{-i} + \rho P_{-i}^{tep}) - (2n+1)(c_i + \rho P_i^{tep})}{2n+1}\right]^2 + \left[\frac{P_i^{tep} - \beta_{ij}}{2}\right]^2 + P_i^{tep}\bar{e}_{ij} \quad (13)$$

From the Third term in equation [13], the initial permits allocation $\bar{e}_{ij}$ appears as a capital gift that lead to a form of implicit subsidy. This "windfall" profit represents an inequality in firms' financial position and might eventually alter competitive relation between firm, if the distribution of grandfathered permits is design in a strategic fashion.

2.2 The equilibrium in permits

Equalization of marginal abatement cost [condition 15] between firms yields to an efficient distribution of abatement efforts that minimize total cost of compliance. Using the envelop theorem, the Nash bargaining equilibrium in the permits market is given by [Spulber, 1989]:

$$\sum_{j=1}^{n} NE_{ij} = 0 \qquad \text{for } i, -i = d, f \text{ and } j, -j = 1, ..., n \quad (14)$$

$$A'_{ij} = A'_{i-j} = P_i^{tep} \quad (15)$$

In equilibrium the permits price P_i^{tep} clears the permits market, is:

$$P_i^{tep} = \frac{\Omega[\sum_{j=1}^{n} \frac{\beta_{ij}}{2} + \hat{E}_i - \bar{E}_i] + \Delta[\sum_{j=1}^{n} \frac{\beta_{-ij}}{2} + \hat{E}_{-i} - \bar{E}_{-i}]}{\Omega^2 - \Delta^2} \quad (16)$$

$$\text{with} \quad \Omega = \frac{n}{2} + \frac{n(1+n)\rho^2}{2n+1} \quad \text{and} \quad \Delta = \frac{n^2\rho^2}{2n+1} \quad , \quad \Omega > \Delta$$

The equilibrium permits price depends on the aggregate emission cap level $\bar{E}_i$ and remains independent from the mode of the initial permits distribution. It reflects also the weighted sum of the marginal costs of abatement and it is linked to the abatement target $(\hat{E}_i - \bar{E}_i)$ of the environmental policy in both countries.

2.3 The comparative statics properties of the equilibrium

Consider now the impact of the change in abatement requirement in the domestic permits program. Using the preceding values of the equilibrium in permits, the variation of permits price in the domestic and the foreign country due to a change in the initial amount of permits grandfathered is determined by:

$$\frac{\partial P_h^{tep}}{\partial \Psi_h^*} = -\rho \hat{Q}_d \frac{\Omega}{\Omega^2 - \Delta^2} < 0 \tag{17}$$

$$\frac{\partial P_f^{tep}}{\partial \Psi_h^*} = -\rho \hat{Q}_d \frac{\Delta}{\Omega^2 - \Delta^2} < 0 \tag{18}$$

where the uperscript $*$ denotes the first-best variables' value.

Lemma 2 *Both countries' permits price are decreasing with the initial cap of permits distributed by the regulator in the domestic country.*

Thus the higher the quantity of permits initially allocated, *ie.* the lower the environmental constraint, the lower the permits prices owning to less emissions abated. Hence, as the home government decide to tighten its environmental abatement requirement, meaning a lower global initial allowance of emission permits $\bar{E}_h^*$, then the permits price remains higher. It follows by comparing equation [17] and [18] that the increase in the distribution of permits in the Home country has a larger effect on its won permits price than on its foreign rival's. The logic of this result can be explained by the interaction existing between countries transmitted by their respective industries through competition in the international product market.

The total impact of change in the distribution of permits in the Home country on the aggregate levels of output can be obtained by signing the following cross-derivatives using equations

$$\frac{dQ_h}{d\bar{E}_h^*} = \sum_{j=1}^{n} \left[\frac{dq_{hj}}{dP_h^{tep}} \frac{dP_h^{tep}}{d\bar{E}_h^*} + \frac{dq_{hj}}{dP_f^{tep}} \frac{dP_f^{tep}}{d\bar{E}_h^*} \right] = \frac{n\rho}{2n+1} \left[\frac{(n+1)\Omega - n\Delta}{\Omega^2 - \Delta^2} \right] > 0 \tag{19}$$

$$\frac{dQ_f}{d\bar{E}_h^*} = \sum_{j=1}^{n} \left[\frac{dq_{fj}}{dP_f^{tep}} \frac{dP_f^{tep}}{d\bar{E}_h^*} + \frac{dq_{fj}}{dP_h^{tep}} \frac{dP_h^{tep}}{d\bar{E}_h^*} \right] = \frac{n\rho}{2n+1} \left[\frac{(n+1)\Delta - n\Omega}{\Omega^2 - \Delta^2} \right] < 0 \tag{20}$$

Proposition 3 *The Home country's aggregate level of output is increasing with the initial cap of permits issued at the expense of the Foreign country's.*

This condition guarantees that the total effects of a tightening in the distribution of permits in the Home country on its domestic aggregate level of output is positive. Nevertheless, we can characterize two opposite directions about this influence:

1. a "*direct price effect*" via the domestic permits price. The permits price in the Home country P_h^{tep} is decreasing with the amount of permits initially allocated. Then, the costs of compliance are less important as the domestic firms face initially a lower pollution abatement requirements. This leads to an increase in their level of production in comparison with their foreign rival competitors.

2. an "*indirect competitive effect*" via the foreign permits price. As previously established, the permits price in the foreign country is also decreasing with the amount of permits initially distributed in the Home country. Hence, it is because a less stringent distribution of permits in the Home country result in reduced Home permits price P_h^{tep}. This leads the Home firms to expand their output, which *ceteris paribus* imply a drop in the Foreign level of output, reducing in turn Foreign emissions. Then, the Foreign permits price is lessening.

This complete the analysis of the market strategy, where Ψ_i is treated as exogenous. Now, we consider the preceding stage in which each government sets a distribution of permits resulting from welfare maximization.

2.4 The choice of environmental regulation policy

Let's now turn to the first stage of the game, where the government in the domestic and the foreign country is fully aware of how its environmental policy will affect the trade equilibrium in the second stage. In this section, we analyze alternatively different governmental actions, considering the case for an optimal or a strategic distribution of emission permits. Each government set non-cooperatively its initial abatement requirement associated to Ψ_i (with $i = h, f$) in order to maximize its social welfare W_i. Emissions of pollution harms the environment in the Home and the Foreign country. So, this assumption implies transboundary pollution and reinforce the incentive for ecological dumping in the distribution of permits (namely trying to shift production from abroad and in turn reducing any associated transboundary pollution). Consider the environmental damage D_i noted by $D_i(\bar{E}_i, \bar{E}_{-i})$. The assumption being made is that the environmental damage depends on the level of overall emissions, as there is perfect compliance in emission trading.

Each government maximizes its social welfare, given by the aggregate national industry profit earned on the international product market net of the environmental damages. Due to no surplus from consumption in this model, governments ignores the usual loss in consumer surplus from imperfect competition in output. Throughout the whole analysis in the first stage of the game, each government will consider that its local firms are maximizing profits for any permits cap schedule.

2.4.1 The optimal distribution of permits

To begin with, consider the case for an optimal distribution of permits so that governments do not act strategically. Each government specifies its abatement requirement Ψ_i it wants its domestic industry to meet, taking as given the decision of the foreign country. Hence, its welfare maximization problem is:

$$\max_{\Psi_i} W_i = \sum_{j=1}^{n} \Pi_{ij}(q_{ij}, \Psi_i) - D_i(\Psi_i, \Psi_{-i}) \text{ for } i, -i = h, f \tag{21}$$

The first-order condition for an optimal allocation of permits is:

$$\frac{dW_i}{d\Psi_i} = \sum_{i=1}^{n} \frac{d\Pi_{ij}}{d\Psi_i} - \frac{dD_i}{d\Psi_i} = 0 \tag{22}$$

This relation points out the optimality rule: the cap in the permits market is set to the level where the marginal damage function equals the marginal benefit achieved by the marginal profits. Equation [22] implicitly determines the total quantity of permits issued is chosen so that the market for quotas creates the correct incentive for firms to reduce their level of pollution. The Optimal Distribution of Permits with the confines of non-cooperative equilibrium is determined by Ψ_i^{opt} for $i = h, f$:

2.4.2 The strategic distribution of permits

Now suppose the Home government has an incentive to engage in a strategic behavior and tries to distort its distribution of permits to shift rents towards its domestic firms. The Home government can commit itself to a strategic distribution of permits taking account of the possibility to raise the output of its industry at the expense of lower output by its foreign rivals. The reason of strategic intervention is that the Home government thinks it can credibly manipulate market shares on the international output market through its choice of abatement requirement.

In the case of the strategic distribution of emission permits, the Home government maximizes its social welfare W_d, assuming the first-order condition to firms and taking account that the government in the foreign country sets its first-best distribution of permits Ψ_f^{opt}. The Home government's welfare maximizing program is given by:

$$\begin{cases} \max\limits_{\Psi_h} \sum\limits_{j=1}^{n} \pi_{hj}(q_{hj}, \Psi_h) - D(\Psi_h, \Psi_f) \\ st. \ \frac{dW_f}{d\Psi f} = \sum\limits_{j=1}^{n} \frac{d\pi_{fj}}{d\Psi_f} - \frac{dD}{d\Psi_f} = 0 \\ st. \ \frac{d\pi_{ij}}{dq_{ij}} = 0 \text{ for } j = 1, ..., n \text{ and } i = h, f \end{cases} \tag{23}$$

The first-order condition for a strategic allocation of permits is:

$$\frac{dW_h}{d\Psi_h} + \left[\sum_{j=1}^{n} \sum_{\substack{k=1 \\ k \neq j}}^{n} \frac{d\pi_{hj}}{dq_{hk}} \frac{dq_{hk}}{d\Psi_h} + \sum_{j=1}^{n} \frac{d\pi_{hj}}{dQ_f} \frac{dQ_f}{d\Psi_h} \right] = 0 \tag{24}$$

For a given level of output, the second term between brackets is positive (see Appendix 1). Hence, the Home government sets its abatement requirement objectives, corresponding to its cap in permits allowances, to the level where the marginal damage exceeds the marginal benefits. This term between brackets can be interpreted as the strategic trade incentive for the Home regulator to deviate from its optimal distribution of permits. Thus, the Home government use its environmental policy to encourage its domestic industry to produce more, as it calculates that the foreign firms will respond by reducing its output level, thereby raising the profit of its domestic firms.

Proposition 4 *The Strategic Distribution of Permits Ψ_h^{strat} is higher than the Optimal Distribution of Permits Ψ_h^{opt}. Then, the Home government loosens its abatement requirements objectives and set a greater cap of permits allowances to shift rents in favour of its domestic producers.*

Equation [24] defines Ψ_h^{strat} the Home country's Strategic Distribution of Permits Ψ_h^{strat}. If the Home government uses environmental policy strategically, implementing a lenient distribution of permits in comparison with the optimal level, the environmental cost of production activities isn't completely internalize. Then, the Strategic Distribution of Permits Ψ_h^{strat} results in two elements: the first one, which reflects the marginal social cost of pollution, and, the other one, equivalent to an optimal export subsidy, which reflects the possibility of shifting production to the domestic suppliers from abroad.

3 Interpretation and comments

The key insight is that the design of the tradable emission permits market in the Home country may be affected by strategic consideration. In this framework of imperfect competition in the international product market, producers earn rents, which provide an incentives for the Home government to distort its environmental policy as a surrogate of traditional trade instruments. The scope of "ecological dumping" can be extended to the repercussion of the distribution of permits on the international competitiveness.

The implication of relaxing the environmental abatement requirements in the Home country from the first-best acts to set a less stringent cap of emission permits, *ie.* $\Psi_h^{opt} < \Psi_h^{strat}$. Then, the Home government expands its distribution of permits in order to shift rents in favour of its domestic firms, by granting them a cost advantage. This Strategic Distribution of Permits represents an "implicit subsidy" to the domestic industry by means of weaker pollution targets. The reaction function of the domestic suppliers have been derived for a particular magnitude of abatement requirements. As the cap of emission permits is raising, these reaction function are slopping outwards that will in turn boost the domestic level of output. This additional domestic output leads to cut the marginal revenue faced by the foreign producers, which reduce their output according to the Cournot-Nash conjecture. Thereby, it will raise the marginal revenue of the domestic firms, thus, prompting them to generate higher profits and to improve their market share in non cooperative rivalries at the expense of the foreign firms.

Since the Home government deviates from its optimal distribution of permits, then, it relaxes its environmental policy towards a level below the marginal damage cost. It follows that the Home producers expand output above the optimal level $\tilde{q}_{ij}$. This extra output will generate additional pollution in the Home country and introduce a marginal welfare deadweight-loss. Nevertheless, this latter effect is outweighed by the foreign output contraction inducing a reduction in foreign emissions. And so transfrontier pollution is reduced, resulting in what has been called "carbon-leackage". As the slope of the foreign firm's reaction function curve is $-1/2$, an increase by one unit in domestic output due to a larger distribution of permits is matched by a decrease in foreign output by two units. Thus, it causes a reduction in the foreign emissions twice as much as the domestic. The net effect is negative, so that the global pollution falls and the environmental damage is reduced.

This implies a higher domestic welfare as the Home regulator implements a strategic distribution of permits.

4 Conclusion

This paper examines the strategic trade implication of permits trading within the Brander-Spencer framework. It shows that if a government acts strategically in its distribution of permits, in a context of imperfect competition in the international product market, then its domestic firm may improve their competitiveness. Indeed, the strategic distribution of permits results to loosen the environmental constraint objective and to allocate more permits compared to the optimal level. Our findings also emphasize that the strategic distribution of permits alters the competitive relation between firms by deterring the foreign rivals' production and reshifting product market shares between from the foreign to the domestic firms.

Further interesting extensions of this model could be proposed. The strategic distribution of permits may be done by differences in the domestic allocation procedures of permits. If the domestic and the foreign regulator adopt different regimes of permits distribution (grandfathering vs auctioning) under an identical binding exogenous constraints on pollution, then competition in the international product market may be distorted. The difference in design of the abatement requirement objectives in a tradable emission permits regulation between upstream and downstream industry provide also possibility of strategic environmental trade policy. All these idea support a claim that governments may engage in environmental policy coordination to implement permits trading regulation in order to prevent from altering global international trade conditions.

5 Notation

q_{ij}	output of the representative firm j in country i
Q_i	total output of country i
c_i	cost of production in country i
p	inverse demand in the third country
Π_{ij}	profit of the firm j in country i
e_{ij}	emission of the firm j in country i
ρ	pollution rate per unit of production
α_{ij}	abatement effort of the firm j in country i
A_{ij}	abatement cost of the firm j in country i
β_{ij}	technological abatement parameter of the firm j in country i
$\bar{E}_i$	cap of permits distribution in country i
Ψ_i	degree of abatement requirement objective in country i
$\bar{e}_{ij}$	initial permits endowment of the firm j in country i
NE_{ij}	net demand for permits of the firm j in country i
P_i^{tep}	permits price in country i
W_i	social welfare in country i
D	environmental damage from pollution
$\hat{}$	variables 'value at the trade equilibrium without any environmental regulation
$\sim$	variables' value at the trade equilibrium with permits trading
$*$	first-best variables 'value

6 Appendix

In this appendix, let's provide arguments that the Home government sets its strategic distribution of permits to the point where the marginal environmental damage exceeds the marginal benefit. The first order condition for strategic welfare maximization is :

$$\frac{dW_h}{d\Psi_h} + \left[\sum_{j=1}^{n} \sum_{\substack{k=1 \\ k \neq j}}^{n} \frac{d\pi_{hj}}{dq_{hk}} \frac{dq_{hk}}{d\Psi_h} + \sum_{j=1}^{n} \frac{d\pi_{hj}}{dQ_f} \frac{dQ_f}{d\Psi_h} \right] = 0 \tag{25}$$

Using conditons [10] and [17], we obtain the sign of the term in brackets as follows:

$$\sum_{j=1}^{n}\sum_{\substack{k=1\\k\neq j}}^{n}\frac{d\pi_{hj}}{dq_{hk}}\frac{dq_{hk}}{d\Psi_h}+\sum_{j=1}^{n}\frac{d\pi_{hj}}{dQ_f}\frac{dQ_f}{d\Psi_h}=[-(n-1)nq_{hj}\frac{dq_{hj}}{d\Psi_h}-n^2q_{hj}\frac{dq_{fj}}{d\Psi_h}]>0$$

This term is positive.

7 References

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